A

DESCRIPTION

OF AN

ACCURATE AND SIMPLE METHOD

OF ADJUSTING

HADLEY's QUADRANT

FOR THE

BACK OBSERVATION.

BY

MR. ROBERT BLAIR.

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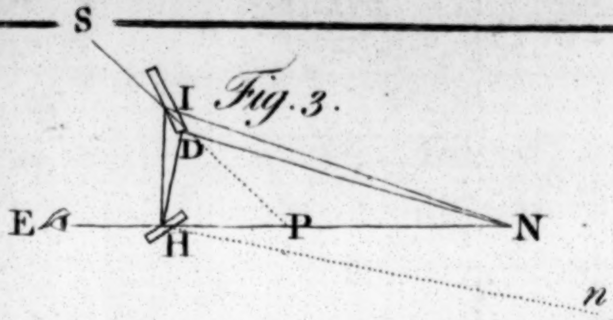
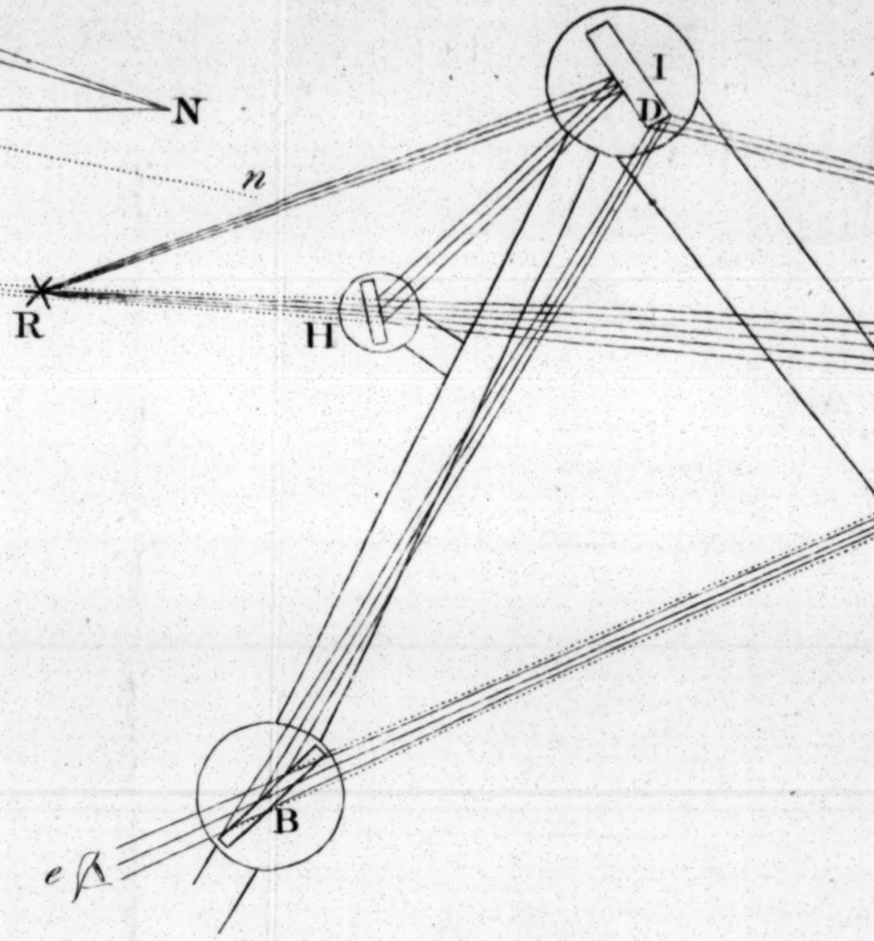


Fig. 3.



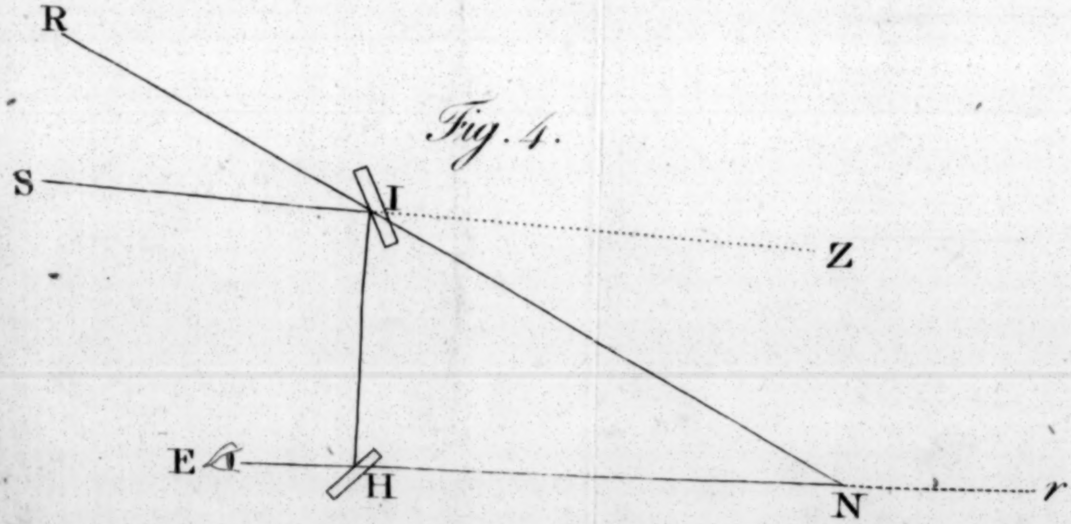


Fig. 4.

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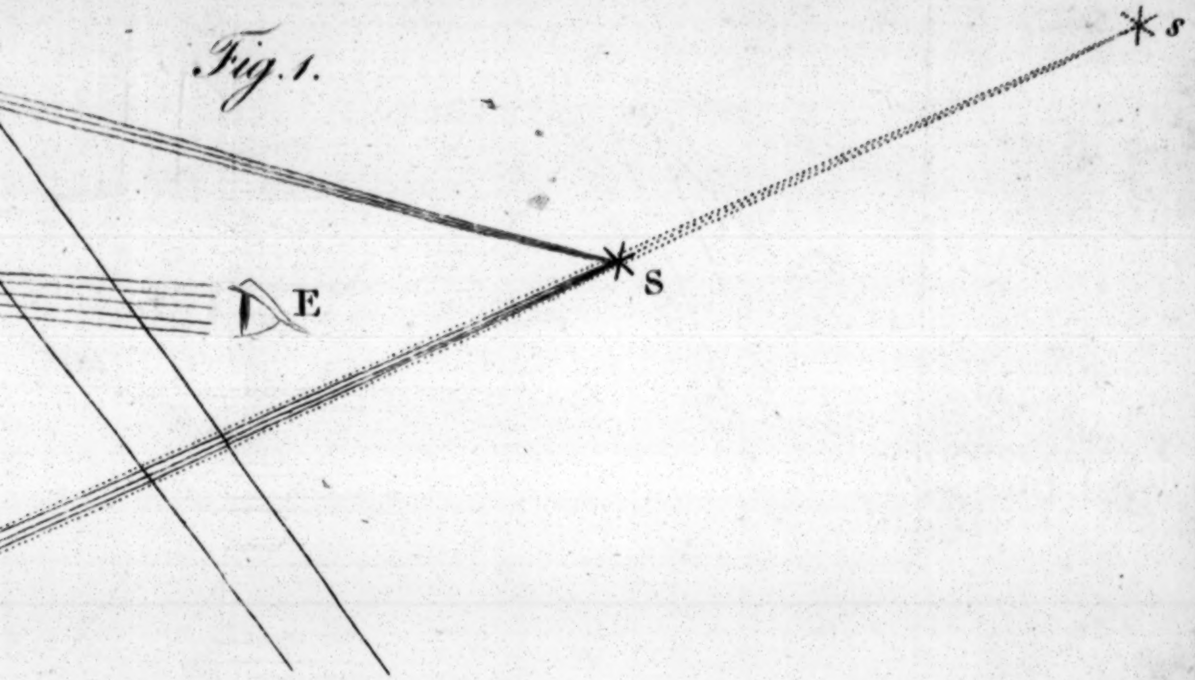

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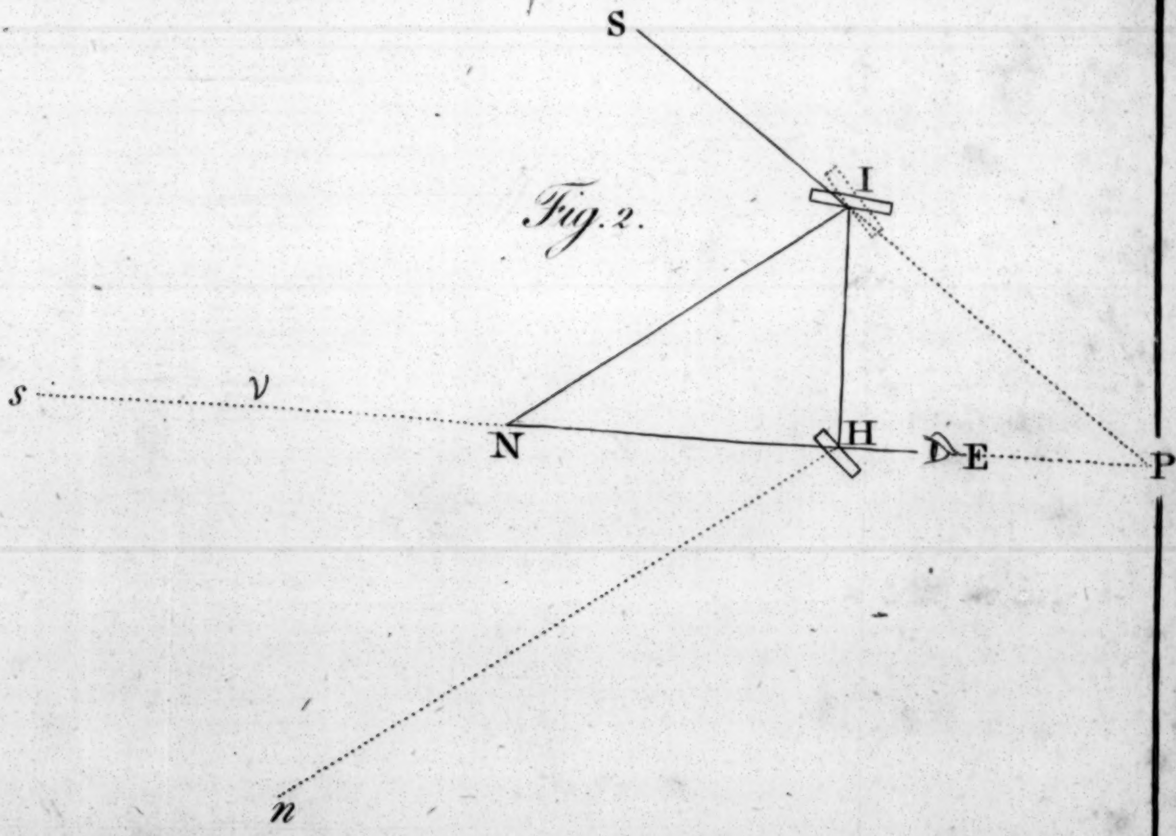

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A DESCRIPTION of an accurate and ſimple Method of adjuſting HADLEY's *Quadrant for the back Obſervation. By Mr.* ROBERT BLAIR.

TO adjuſt HADLEY's Quadrant for the back Obſervation by the Method propoſed, no additional Apparatus is neceſſary. All that is required is to poliſh the lower Edge of the Index-glaſs, and expoſe it to View. The back Horizon-glaſs is adjuſted by means of a Reflexion from this poliſhed Edge, in the very ſame Manner as the fore Horizon-glaſs is adjuſted by the common Method.

To thoſe who are acquainted with the Theory of the Quadrant, very little more need be ſaid on the Subject. They will immediately perceive, that in the ſame Manner as the fore Horizon-glaſs can at any time be placed parallel with the reflecting Surface of the Index-glaſs, by bringing the Image of a diſtant Object, after Reflexion from theſe Two Surfaces, to coincide with the Object itſelf ſeen directly; ſo alſo may the back Horizon-glaſs be placed parallel with the poliſhed reflecting Edge of the Index-glaſs, by a ſimilar Operation; and that, as the poliſhed Surface of this Edge is at Right-angles to the ſilvered Surface of the Index-glaſs, the reflecting Surface of the back Horizon-glaſs muſt be ſo likewiſe. That is, the Quadrant will

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then be adjuſted for the back Obſervation. For the Adjuſtment of the back Horizon-glaſs conſiſts in placing it perpendicular to the Index-glaſs, when the Index is at o, and alſo perpendicular to the Plane of the Quadrant; both of which Points are obtained by this Operation; provided the reflecting Edge is perpendicular to the Plane of the Quadrant. It is the Buſineſs of the Inſtrument-maker to give this Edge the true Poſition, as well as the ſilvered Surface, at the Firſt Conſtruction; after which, it has been uſual to take it for granted, that they will never alter. And it may be remarked, that the Edge is the leaſt liable of the two to any Alteration of Poſition from Accidents.

It would ſeem, however, an Advantage gained to the Inſtrument, if, in the little Pamphlet, which generally accompanies the Sale of this Inſtrument, ſome ready Method were pointed out, by which the Obſerver might, at any time, ſatisfy himſelf of the Truth of this Matter in both Caſes.

A clearer Idea of what has been ſaid above will, perhaps, be obtained by caſting the Eye on Fig. I. where R I H E repreſents a Pencil of Rays emitted from the Object R, incident on the Index-glaſs I, from which it is reflected to the fore Horizon-glaſs H, and thence to the Eye at E. By this double Reflexion an Image of the Object is formed at *r*. R H E repreſents another Pencil from the ſame Object R, coming directly through the fore Horizon-glaſs to the Eye at E. So that the doubly reflected Image *r*, appears coincident with the Object R itſelf, ſeen directly.

When this Coincidence is perfect, and the Object R ſo very diſtant as to make the Angle I R H inſenſible, the Poſition of the Speculums I and H will differ inſenſibly from Paralleliſm; that is, the Quadrant will be adjuſted for the fore Obſervation. Now it is from the Eaſe and Accuracy, with which this Adjuſtment can at any time be made, that the fore Obſervation derives its Superiority over the back Obſervation. But by grinding the Edge of the Index-glaſs perpendicular to its reflecting Surface, and poliſhing it, the back Horizon-glaſs is rendered capable of an Adjuſtment equally eaſy and accurate as the fore Horizon-glaſs. For by a Pencil of Rays emitted from the Object S, incident on the reflecting Edge of the Index-glaſs D, thence reflected to the back Horizon-glaſs B, and from that to the Eye at *e*, an Image is formed at *s*; which Image being made to coincide with the Object S itſelf, ſeen directly, aſcertains the Poſition of the back Horizon-glaſs, relative to the Index-glaſs, with the ſame Preciſion, and in a Manner equally direct, as the former Operation does that of the fore Horizon-glaſs.

One of the firſt Difficulties that occurred, in perfecting this Method of adjuſting the back Horizon-glaſs, was to grind the Surface of the reflecting Edge accurately perpendicular to the ſilvered Surface; but by uſing a Method ſomewhat ſimilar to that by which the Two Surfaces of a Plate of Glaſs can be ground ſo nearly parallel as to make the Error inſenſible, an equal Degree of Accuracy may be obtained in grinding ſuch Surfaces perpendicular. And even if this had not been the Caſe, the propoſed Method of Adjuſtment would be very little affected by any Error committed in this Reſpect. For there are ſeveral Ways of finding any Deviation from the perpendicular Poſition, to the greateſt Nicety. And this once found, it is only neceſſary to make a Mark on the Arch of Exceſs, where the Index is to be placed, at the time of adjuſting, inſtead of placing it at O.

Another Objection, which, it was feared, would not have been ſo eaſily ſurmounted, aroſe from the ſmall Extent of the Field of View; which is neceſſarily limited by the Thickneſs of the Index-glaſs. But by properly proportioning the Thickneſs of the back Horizon-glaſs to that of the Index-glaſs; ſo as to take Advantage of the Reflexion from both Surfaces of the former, ſuch an Increaſe of Field is obtained, either in obſerving with the naked Eye, or a Teleſcope, but eſpecially in the latter Caſe, as to render it unneceſſary to have Recourſe to any leſs ſimple Method of enlarging it.

It was alſo apprehended, that the Quantity of Light reflected from this poliſhed Edge might, in ſome Caſes, be inſufficient to make the reflected Image ſufficiently perceptible; but by conforming to the practical Directions for adjuſting, which are ſubjoined, no Inconvenience will be felt from this Cauſe.

Directions for adjuſting the back Horizon-glaſs.

THE Method of adjuſting the Quadrant for the back Obſervation is this. If it is to be done without making Uſe of the Teleſcope, place the Index at O, and applying the Eye to the Hole in the Sight-vane *, or Tube for directing the Sight, direct it through the back Horizon-glaſs, to the Horizon; if that is the Object to be uſed for adjuſting. The Two Horizons are then to be made to coincide, holding the Quadrant firſt in a vertical, and then in an horizontal Poſition; by which means both Adjuſtments will be effected as in the fore Obſervation.

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* Beſides the Two Holes in the Sight-vane commonly made, there muſt be a Third nearer to the Horizon-glaſs, and ſo placed that an Eye directed through it to the Center of

There will be no Difficulty in finding the reflected Horizon, if the Obſerver firſt directs his Eye to that Part of the Horizon-glaſs, where he obſerves the Image of the poliſhed Edge of the Index-glaſs; which will appear double. When the direct Horizon is made to appear in this Space, the reflected one will be ſeen cloſe by it, unleſs the Inſtrument wants a great Adjuſtment; in this Caſe a little Motion of the back Horizon-glaſs backwards and forwards, will preſently bring it in View.

When the Horizon, or any obſcure terreſtrial Object, is to be made Uſe of for adjuſting by means of the reflecting Edge, there is a Precaution to be taken, without which, the Obſerver will ſometimes meet with, what will appear an unaccountable Difficulty. For if the Sky, or other Object behind him, ſhould happen to be pretty bright, he will not be able to diſcern the Horizon at all. This ariſes from the Image of the Object behind him, which is reflected from the ſilvered Surface of the Index-glaſs, appearing to coincide with the Horizon; in which Caſe, the bright Picture

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of the Horizon-glaſs, ſhall there perceive the Image of the poliſhed Edge of the Index-glaſs. This Hole muſt not be made ſmall like the others, but equal to the ordinary Size of the Pupil of the Eye; there being, on ſome Occaſions, no Light to ſpare.

ture of the former, which is formed in the Bottom of the Eye, prevents the fainter Impreſſion of the latter from being perceived.

This will be avoided, either by applying a black Screen over the ſilvered Surface of the Index-glaſs; or, without being at this Trouble, by ſtanding at a Door or Window, ſo that only the dark Objects within can be reflected from the Index-glaſs. But if the Obſervation is to be made in the open Air, a Hat, or any ſuch dark Obſtacle, held before the ſilvered Surface of the Index-glaſs, will very effectually remove this Inconvenience.

Some ſuch Precaution muſt alſo be taken, when a Teleſcope is made Uſe of. And, moreover, the Teleſcope muſt be brought ſo near to the Plane of the Quadrant, that the greateſt Part of its Aperture ſhall be oppoſed to the ſilvered Half of the Horizon-glaſs; ſo as to make the direct and reflected Horizons of equal Brightneſs.

If the Teleſcope is to be uſed in adjuſting, the firſt thing to be done, after fixing it for the back Obſervation, is to alter the Direction of its Axis, from the Center of the Index-glaſs to the Edge. The Teleſcope is ſo contrived, as to admit of the ſmall Degree of Motion, which is neceſſary for this Purpoſe. If this is omitted, the Field will be more contracted than otherwiſe; and the reflected Object will always appear on one Side of the Field of the Teleſcope.

The Sun has been found to be the beſt Object for adjuſting the Quadrant accurately. The Method of doing this for the fore Obſervation, by firſt bringing the two Suns into one, whereby both Adjuſtments are effected at once, and then meaſuring the Sun's Diameter twice, by which greater Accuracy will be obtained in the principal Adjuſtment, which has been deſcribed by the Aſtronomer Royal in the Requiſite Tables, is ſo applicable to the preſent Method of adjuſting the back Horizon-glaſs, as to make a Repetition of it unneceſſary.

One thing only, it may not be improper juſt to take Notice of. The beſt Obſervers, inſtead of making the principal Adjuſtment, place the Speculums parallel by moving the Index, without altering the Poſition of the Horizon-glaſs. This will be found preferable to the common Method both for Eaſe and Accuracy; and beſides, poſſeſſes a very material Advantage in admitting a more ſimple Conſtruction of the Inſtrument. For the complex Apparatus intended for making the principal Adjuſtment of the Horizon-glaſſes is thereby rendered unneceſſary.

If this Method is adopted, it will generally be found on examining the Poſition of the Index, after having placed the Speculums parallel, that it does not point to the Beginning of the Arch; ſo that it becomes neceſſary to allow for what has been called the Index-error.

Now it is to be remarked, that in adjuſting the back Horizon-glaſs, this Index-error is to be allowed for contrariwiſe from the Index-error in the fore Obſervation. Thus if the Index-error is on the Arch of Exceſs, it is to be added to all Angles meaſured by the fore Obſervation, and ſubtracted from all Angles meaſured by the back Obſervation; and, *vice verſa*, if this Index-error is on the proper Arch of the Quadrant. Or it will amount to the ſame thing if the Index-error is allowed for the ſame

Way in both Caſes, provided that you add or ſubtract it, in the back Obſervation, to the Angle marked by the Index, before ſubtracting this Angle from 180°, to find its Supplement, which is the required angular Diſtance of the Objects *.

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* Though rather foreign to the Intention of this paper, it may not be amiſs to take Notice of a Source of Error in obſerving by HADLEY's Quadrant, which, there is Reaſon to apprehend, is not ſo generally known, and attended to, as it ought to be.

The Errors here meant are thoſe which ariſe from the Bending and Elaſticity of the Index, and the Reſiſtance which it meets with in turning round its Center; whence the Extremity of the Index, on being puſhed along the Arc, will advance ſenſibly, before the Index-glaſs begins to move: and may be ſeen to recoil, when the Force acting on it is removed. Mr. HADLEY ſeems to have been apprehenſive that his Inſtrument would be liable to Errors from this Cauſe; and, in order to avoid them, gives particular Directions that the Index be made broad at the End next the Center, and that the Center, or Axis itſelf, have as eaſy a Motion as is conſiſtent with Steadineſs; that is, an entire Freedom from Looſeneſs, or *Shake*, as the Workmen term it. By ſtrictly complying with theſe Directions the Error in queſtion may indeed be greatly diminiſhed; ſo far, perhaps, as to render it nearly inſenſible, where the Index is made ſtrong, and the proper Medium between the two Extremes of a *Shake* at the Center on one Hand, and too much Stiffneſs there on the other, is nicely hit; but it cannot be entirely corrected. For to more or leſs of bending the Index will always be ſubject: and ſome Degree of Reſiſtance will remain at the Center, unleſs the Friction there could be totally removed; which is impoſſible.

Of the Reality of the Error to which he is liable from this Cauſe, the Obſerver, if he is provided with a Quadrant furniſhed with a Screw for moving the Index gradually, may thus ſatisfy himſelf. After finiſhing the Obſervation lay the Quadrant on a Table, and note the Angle; then cautiouſly looſen the Screw which faſtens the Index, and it will immediately, if the Quadrant is not remarkably well conſtructed,

Of a Correction neceſſary in finding the angular Diſtance of near Objects.

AS the Uſe of HADLEY's Quadrant is not confined to aſtronomical Obſervations, but may alſo be extended to determining the angular Diſtance of near Objects in taking Surveys; it becomes

be ſeen to ſtart from its former Situation; more or leſs according to the Perfection of the Joint, and the Strength of the Index. This Starting, which is owing to the Index recoiling after being releaſed from the confined State it was in during the Obſervation, will ſometimes amount to ſeveral Minutes; and its Direction will be oppoſite to that, in which the Index was moved by the Screw at the time of finiſhing the Obſervation. But how far it affects the Truth of the Obſervation, depends on the Manner in which the Index was moved in ſetting it to o for adjuſting the Inſtrument; or in finiſhing the Obſervations neceſſary for finding the Index-error.

This will, perhaps, be beſt underſtood by ſtating a Caſe in which the Error of the Obſervation ariſing from this Cauſe will amount to the greateſt poſſible. Suppoſe, then, Two Obſervers with Inſtruments equally good, to have made the following Obſervations. One in ſetting the Index of his Quadrant at o, in order to adjuſt it, happens to move it in a retrograde Direction. He then obſerves the angular Diſtance of Two Objects, and finiſhes the Obſervation with an advanced Motion of the Index. The other Obſerver, on the contrary, in adjuſting ſets the Index of his Quadrant to o by advancing it, and finiſhes his Obſervation of the angular Diſtance of the ſame Objects by a retrograde Motion of the Index. Now if the Index did not admit of the leaſt Bending, this Difference of Circumſtances would nowiſe affect the Reſult of the Obſervations. But on account of this Bending, the former of theſe Obſervations will be found to exceed, and the latter to fall ſhort of the true angular Diſtance of the Objects, by twice the Quantity which the Index was obſerved to ſtart upon the Arch, when the faſtening Screw was looſened.

A little Conſideration will make it evident, that this Difference proceeds from the Index being bent in a contrary comes neceſſary, in this Caſe, where Accuracy is deſired, to determine the Point of the Inſtrument from which ſuch angular Diſtance is to be eſtimated. For when Mention is made of the angular Diſtance of Two Objects, or Points; the Idea communicated is imperfect, unleſs ſome Third Point

Direction in obſerving from what it was in adjuſting; which oppoſite Bending tends in one Caſe to increaſe and in the other to diminiſh the Angle meaſured.

The general Nature of theſe Errors being thus explained, and their Cauſe appearing to be inſeparable from the Materials and Mode of Conſtruction of the Inſtrument, it only remains to point out the beſt and eaſieſt practical Rule for ſhunning them, which ſeems to be this. In all Obſervations made by HADLEY's Quadrant, let the Obſerver take Notice conſtantly to finiſh his Obſervations, by moving the Index in the ſame Direction, which was uſed in ſetting it to 0 for adjuſting; or in the Obſervations neceſſary for finding the Index-error.

If this Rule is obſerved, the Error ariſing from the Spring of the Index will be obviated. For as the Index was bent the ſame Way, and in the ſame Degree in adjuſting as in obſerving, the Truth of the Obſervations will not be affected by this Bending. As to the Direction itſelf, in which the Index is to be moved both in adjuſting and obſerving, the Obſerver is at Liberty to chuſe; but as the common and moſt convenient Practice in obſerving is to finiſh the Obſervations by a Motion of the Index in that Direction which increaſes the Angle; that is, from 0 towards 90 in the fore Obſervation, and from 90 towards 0 in the back Obſervation; it would, perhaps, be better, if the Obſerver were to adopt it as a general Rule in all Obſervations, of whatever Kind, made by HADLEY's Quadrant, to finiſh the Motion of the Index by puſhing it from him; or turning the Screw in that Direction which carries it farther from him. What is meant by finiſhing the Motion of the Index, in any Direction, is, that the laſt Motion communicated to the Index ſhall have been, for ſome Minutes at leaſt, in the Direction required.

Theſe Errors ariſing from the above-mentioned Imperfection of Quadrants, which have greatly perplexed and embarraſſed Obſervers unacquainted with them, were long ago detected by an Officer of diſtinguiſhed Rank and Character in his

Point is alſo expreſſed, from which this angular Diſtance is to be eſtimated.

Accordingly the Aſtronomer Royal, with his accuſtomed Zeal and Ability in promoting the Intereſts of Science, has, amongſt other uſeful Improvements, given us Directions, in a Paper annexed to the NAUTICAL EPHEMERIS for 1774, how to proceed in ſuch Caſes, both in the fore and back Obſervation. But as the Method here deſcribed of poliſhing the Edge of the Index-glaſs, hath been found to afford an eaſier, and more accurate Method of adjuſting the Inſtrument for the back Obſervation, than any then in Uſe, it becomes neceſſary to explain this Matter a little farther. In order to this, there muſt be premiſed by way of Lemma, a Theorem, the Demonſtration of which, as being eaſily deducible from the well-known optical Axiom, that the Angle of Reflexion is equal to the Angle of Incidence, may be here omitted.

LEMMA.

A RAY of Light after Reflexion from Two plain parallel Surfaces, proceeds parallel to the incident Ray; and if the Two plain reflecting Surfaces are inclined, a Ray of Light incident perpendicular to their common Interſection, will, after Reflexion, form with the incident Ray produced, an Angle, double of that, in which the ſaid Surfaces are inclined; or of its Supplement, if it exceeds a Right-angle.

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his Majeſty's naval Service, and well known in the ſcientific World, who alſo inveſtigated their Cauſe and adopted the proper Method of obviating them. At his Deſire an Account of them is now laid before the Public, as a neceſſary Caution both to the Obſerver and Inſtrument-maker.

Hence it appears, that if the Speculums have been adjuſted parallel when the Index is at O; and afterwards by moving it forwards upon the Arch, the Image of any Object as S (Fig. II.) be made to coincide with any other Object ſeen directly as N; the angular Diſtance of theſe two Objects is equal to twice the Angle in which the Speculums are inclined to one another, which, from the Conſtruction of the Inſtrument, is equal to the Angle ſhown by the Index; ſuch angular Diſtance being eſtimated from the Point P, where the incident Ray S I produced, interſects the doubly reflected Ray H P.

And this holds true in Angles of all Magnitudes, and in Objects ſituated at what Diſtance ſoever. But there is an Objection to eſtimating the Angles from the Point P, becauſe its Situation is variable according to the Magnitude of the Angle meaſured, and lies in ſome Caſes on oppoſite Sides of the Inſtrument, and even at a Diſtance from it.

It is, therefore, required to determine the angular Diſtance when eſtimated from ſome fixed Point, as I the Center of the Index-glaſs. In order to accompliſh this, it becomes neceſſary to add to the Angle marked by the Index, the Angle I N H, which I H, the Diſtance between the Centers of the Speculums, ſubtends at the direct Object N.

This Angle I N H, therefore, muſt next be found: And it will be obtained if, when the Speculums are parallel and the Index at O, the Obſerver looking at the direct Object N, by a ſmall retrograde Motion of the Index, brings its doubly reflected Image, which then appears at *n*, to coincide with it. The Angle marked by the Index on the Arch of Exceſs is that required. For it is equal to the Angle which N I, the incident Ray, forms with H E, the doubly reflected Ray, produced to their Point of Interſection N, which in this Caſe coincides with the direct Object.

Theſe two Angles S P N and I N H, being thus found, their Sum is the Angle ſought; for it is equal to N I S, the Angle which the Objects S and N ſubtend at I, the Center of the Index-glaſs. *Euclid* I. 32.

This will ſuffice to point out the Correction, which it is neceſſary to make in the fore Obſervation, when the Inſtrument is applied to meaſuring the angular Diſtance of near Objects. It is intended to introduce and explain a Correction of the ſame Kind, but more conſiderable, which it is neceſſary to make in the back Obſervation; and which may be obtained, by means of the reflecting Edge, with the ſame Eaſe and Accuracy.

When the doubly reflected Image of any Object S (Fig. III.) is made to coincide with any other Object N ſeen directly through the back Horizon-glaſs, the Speculums having previouſly been adjuſted perpendicular with the Index at O, the Angle marked by the Index is S P E, which the incident Ray S I produced, forms with the doubly reflected Ray H E produced, and S P N, the Supplement of this Angle, is the angular Diſtance of the Objects, eſtimated from the Point P; whether they be near, or remote. But this Point being moveable, as in the fore Obſervation, the angular Diſtance of the Objects is required, when eſtimated from I, the Center of the Index-glaſs. In order to obtain this, the Angle I N H, which the Diſtance between the Speculums ſubtends at the direct Object, muſt be added to the former.

Next, therefore, it becomes neceſſary to determine this Angle. The moſt direct Method of obtaining it, would be by turning round the back Horizon-glaſs, placing it parallel with the Index-glaſs, and then finding the Angle I N H as directed in the fore Obſervation. But beſides that the back Horizon-glaſs is not in general, and ought not to be made capable of being turned round; this Method would, in ſeveral Reſpects, be attended with Trouble and Inconvenience; which will be ſaved by making Uſe of the poliſhed Edge. For when this Edge is placed parallel with the back Horizon-glaſs, an Image of the Object N will be formed at *n*; which by a ſmall Motion of the Index may be made to coincide with N. When this is effected the Angle marked by the Index is D N H, which N D, the incident Ray, forms with H E the doubly reflected Ray produced to their Point of Interſection N. Now though it is true that the Angle D N H, thus found, falls ſhort of I N H, the Angle required, by the ſmall Angle I N D, which half the Length of the Index-glaſs ſubtends at the direct Object; yet this laſt, being always a proportional Part of the former, may eaſily be found and added to it; in the Generality of Quadrants it will amount to about One-fifth Part of it. The Sum of the Angle S P N found by the Inſtrument, and this Angle I N H added together, is the Angle S I N required. *Euclid* I. 32.

It may here be remarked to thoſe who are deſirous of minute Accuracy, that what has been called the Center of the Index-glaſs is not to be literally underſtood as ſuch, unleſs when the Axis of the Teleſcope is at the ſame Diſtance from the Plane of the Quadrant as this Center. For the Point from which the angular Diſtances are to be eſtimated, is always at the ſame Diſtance from the Plane of the Quadrant as the Axis of Viſion; and ſituated ſomewhere in a Line at Right-angles to that Plane, and paſſing through the Center of the Index-glaſs.

There is one Caſe in which the preceding Directions of adding to the Angle given by the Inſtrument the ſmall Angle, which the Centers of the Speculums ſubtend at the direct Object, are not ſtrictly applicable; and that is, when the Angle found by the Inſtrument amounts to 180 Degrees, or differs leſs from it than by the ſmall Angle juſt mentioned. For in this Caſe, as the angular Diſtance of two Objects cannot exceed 180 Degrees, the Addition becomes equivalent to a Subtraction.

Thus if the Inſtrument adjuſted parallel, makes the angular Diſtance of the Objects S and N (Fig. IV.) equal to 180 Degrees; in order to reduce this to the Center of the Index-glaſs, the Angle N I Z, equal to H N I, muſt be ſubtracted from it. For S I N is the angular Diſtance of the two Objects eſtimated from I, which falls ſhort of two Right-angles, by the Angle N I Z, equal, becauſe of the parallel Lines I Z, H N, to the Angle I N H, which the Centers of the Speculums ſubtend at the direct Object.

If R had been the doubly reflected Object, the Angle found by the Inſtrument would be R N *r*, being the Supplement of the Angle R N H, which the incident Ray R I produced, forms with the doubly reflected Ray E H produced, at their Point of Interſection, which in this Caſe coincides with the direct Object N. If to this Angle R N *r* found by the Inſtrument, which is equal to R I Z, there be added the Angle I N H, equal to which is

N I Z;

NIZ; the angular Diſtance of the Objects R, N, eſtimated from I, the Center of the Index-glaſs, will be juſt 180 Degrees.

From the whole there reſults this general Rule, which is equally applicable in the fore and back Obſervation. The Speculums being adjuſted parallel in the fore, and perpendicular in the back Obſervation, firſt find the angular Diſtance of the Objects in the uſual Way; and then, by the Directions juſt given, find the Angle which the Centers of the Speculums ſubtend at the direct Object, taking Care that the Center of the Index-glaſs retain the ſame Poſition in both Obſervations. If the Sum of theſe two Angles is leſs than 180°, that Sum is the angular Diſtance of the Objects eſtimated from the Center of the Index-glaſs. But if this Sum exceeds 180°, the Supplement to 360° is to be taken as the true angular Diſtance of the Objects eſtimated from that Point.

DEFINITION.

AS Mention has been made of near Objects and diſtant Objects, it may be aſked how the Limit between theſe is to be determined? The Anſwer is, that thoſe are to be accounted diſtant Objects, at which the Diſtance between the Speculums does not ſubtend a ſenſible Angle. But without being at any Trouble in calculating this Diſtance, which differs in the fore and back Obſervations, as well as in different Inſtruments; there is an eaſy practical Rule for determining the Matter in all Caſes, which is this. The Quadrant being adjuſted by the Horizon of the Sea, or any of the celeſtial Bodies, obſerve whether the Object, which is to be taken as the direct one, coincides as to Senſe with its reflected Image; if this is the Caſe no Correction is neceſſary, as the Angle given by the Inſtrument will not differ ſenſibly, from the angular Diſtance of the Objects eſtimated from the Center of the Index-glaſs. But otherwiſe, the Correction is to be found and applied, as above directed.

REMARK.

IF the Prejudices againſt the back Obſervation ſhould be got over, it ſeems reaſonable to expect the following Advantages from its Uſe.

The lunar Obſervations will be extended; for the angular Diſtance of the Sun and Moon may be obtained, whenever both theſe Luminaries are viſible, however great that Diſtance may be. And the Sun, beſides the Advantage he poſſeſſes from being ſituated in the Ecliptic, ſo that (his proper Motion excepted) as little as poſſible of the Moon's ſlow Motion is loſt, is deemed a better Object to obſerve by, than a Star. The Altitudes too can be found with more Eaſe and Accuracy, and the whole Proceſs more conveniently conducted in the Day-time, than at Night.

But it is in high Latitudes, that the Practice of the back Obſervation will be found more particularly uſeful. There, during the Summer, the continual Preſence of the Sun, effacing by his Splendour the Appearance of the Stars, leaves no Choice of Objects. And in ſuch Situations the Extenſion of the lunar Obſervations becomes an Object the more deſireable, as the Ship's Longitude may, by their Means, on account of the Smallneſs of the Degrees, be determined ſo very near the Truth.

Beſides theſe Advantages, which the lunar Obſervations may be expected to derive from rendering the Quadrant capable of meaſuring accurately the largeſt Angles; there are other Occaſions, on which the back Obſervation has been recommended, and will be found uſeful. Thus in finding the Latitude, whether by a ſingle Altitude, or two Altitudes with the Time between, and in other Caſes, where Altitudes are wanted, if the Horizon ſhould happen to be bad under the Meridian on one Side, or if it ſhould be obſtructed by a Headland, or Veſſel, the Obſervation may, notwithſtanding, be made with the ſame Accuracy on the oppoſite Side.

The Surveyor on Shore too will be enabled to find the angular Diſtance of near Objects, in all Caſes, with Accuracy; and to determine his Latitude, and on ſome Occaſions his apparent Time, by the Method of Reflexion from the Surface of Quick-ſilver, or any other horizontal reflecting Plane; Problems beyond the Reach of the Sextant conſtructed in the common incomplete Form, without a back Horizon-glaſs, when the Altitude of the Object exceeds 60 Degrees.

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